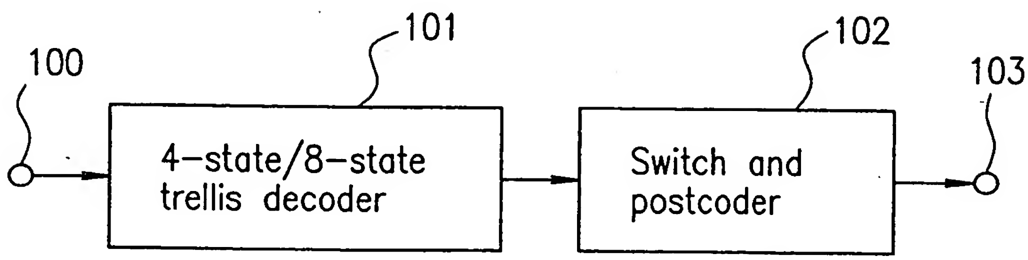
Inventor(s): Hiroyuki Senda, et al.
Title: Error Correction Circuit and Error Correction Method
Customer No. 23122 Atty. Docket No. YAO-4210US1
Express Label No.: EV351884480US

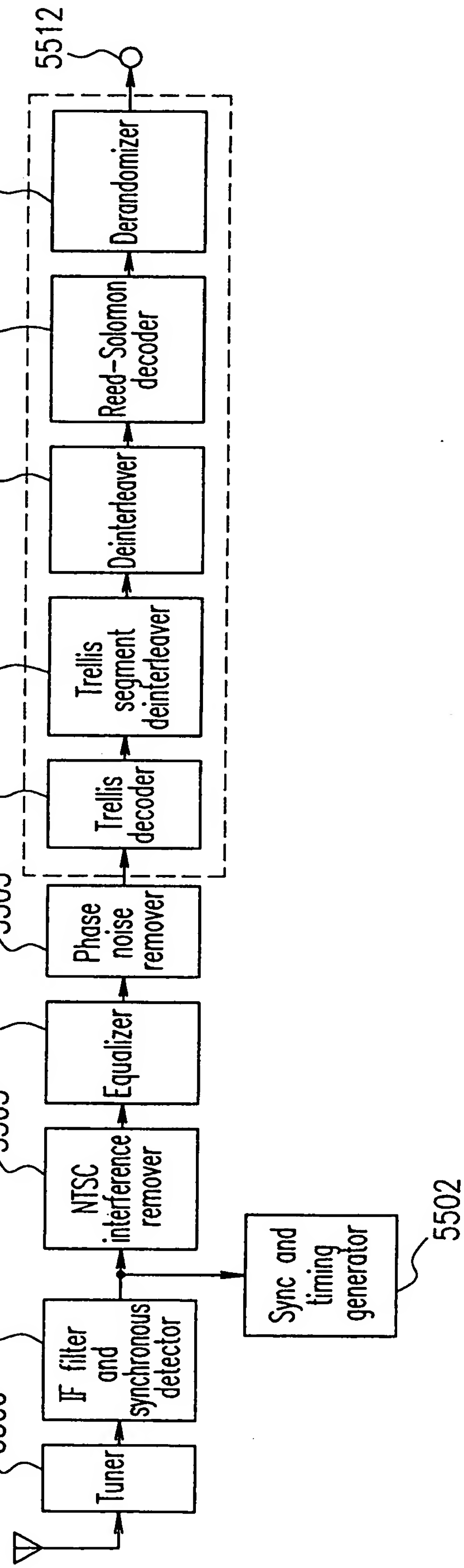
P20567

FIG. 1



P20567

FIG.2


5500
Tuner
5501
IF filter and synchronous detector
5502
Sync and timing generator
5503
NTSC interference remover
5504
Equalizer
5505
Phase noise remover
5507
Trellis decoder
5508
Trellis segment deinterleaver
5509
Deinterleaver
5510
Reed-Solomon decoder
5511
Derandomizer
5512

Inventor(s): Hiroyuki Senda, et al.
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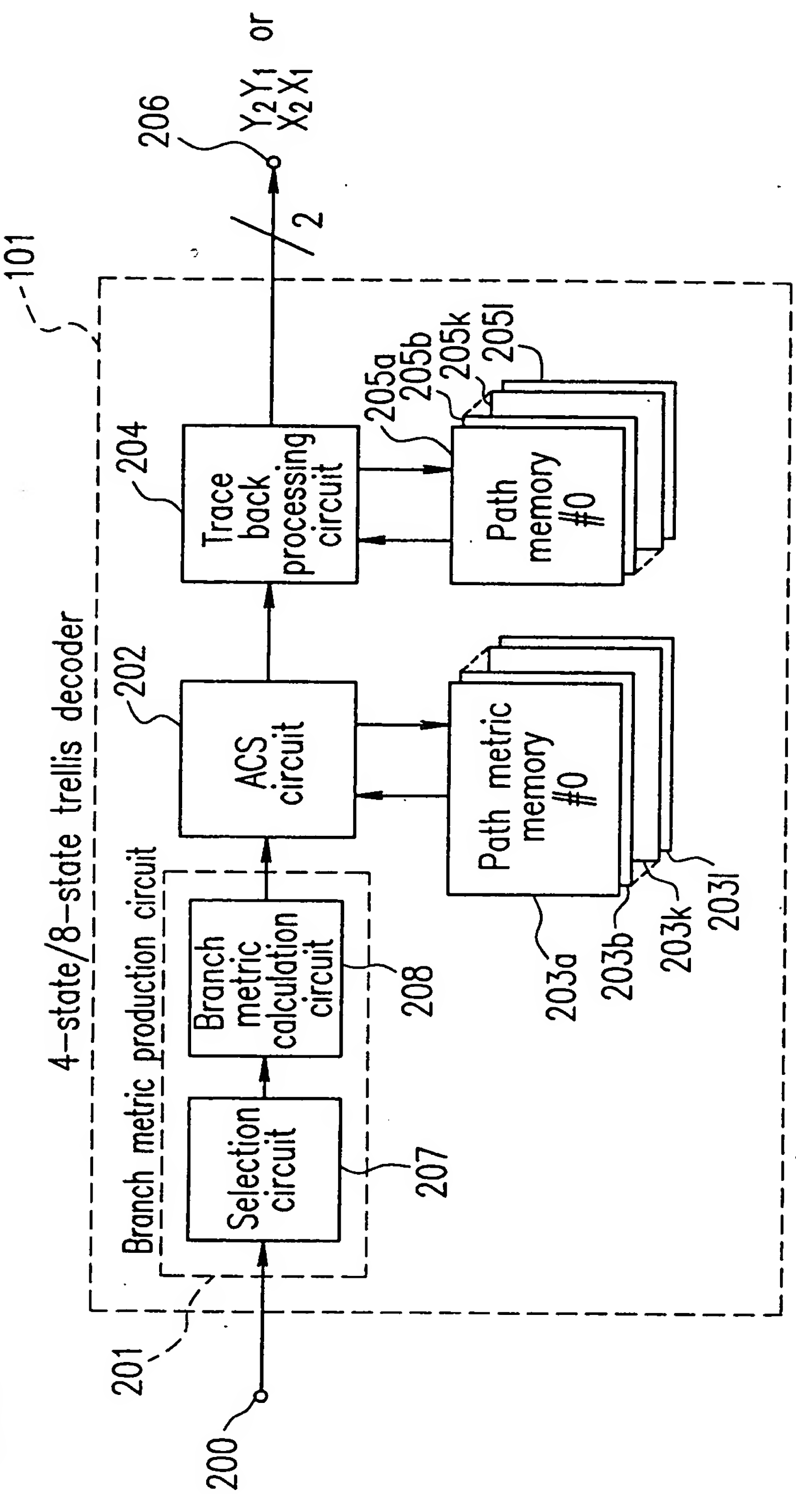
FIG.3



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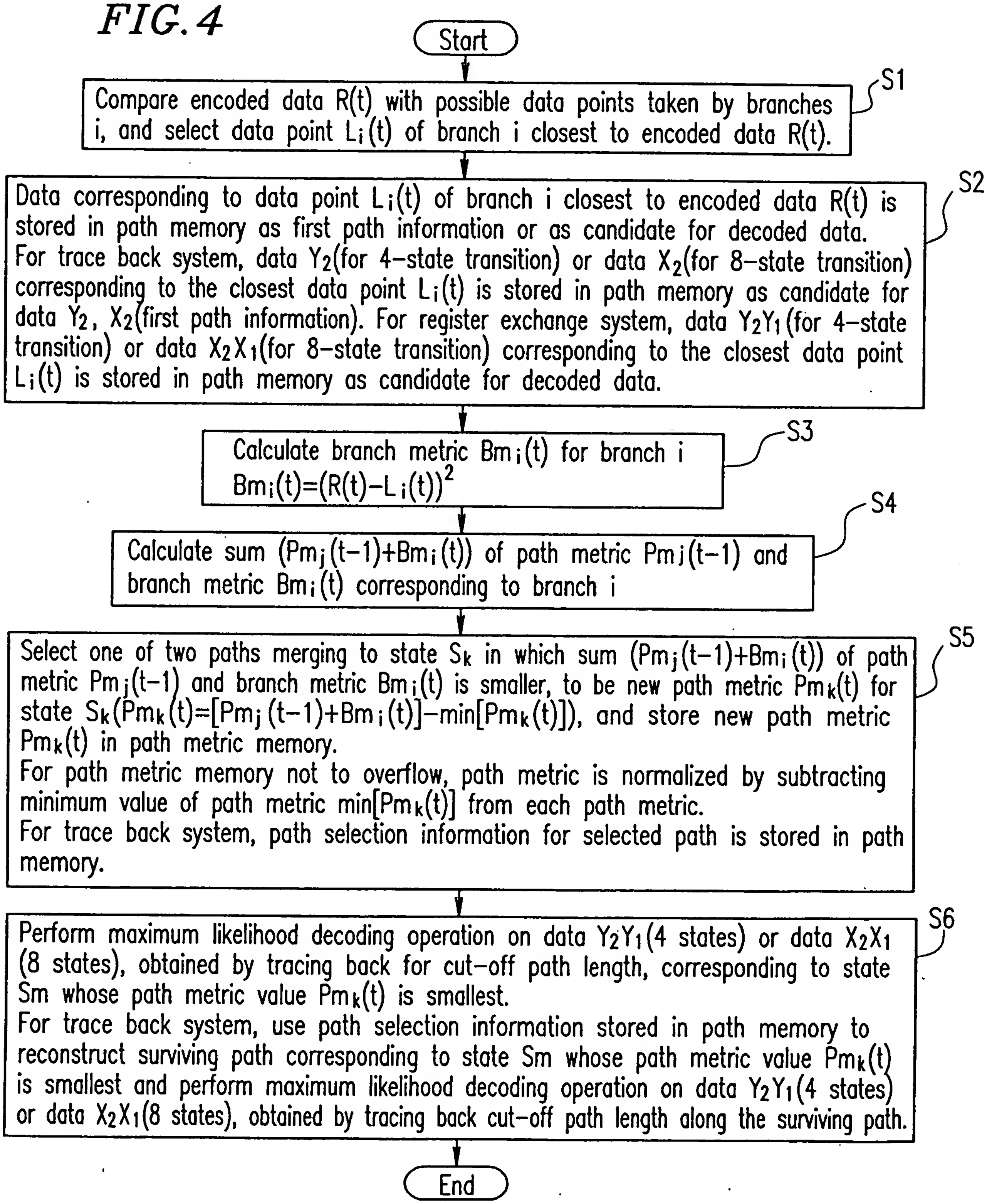
Title: Error Correction Circuit and Error Correction Method
Customer No. 23122 Atty. Docket No. YAO-4210US1
Express Label No.: EV351884480US

FIG. 4



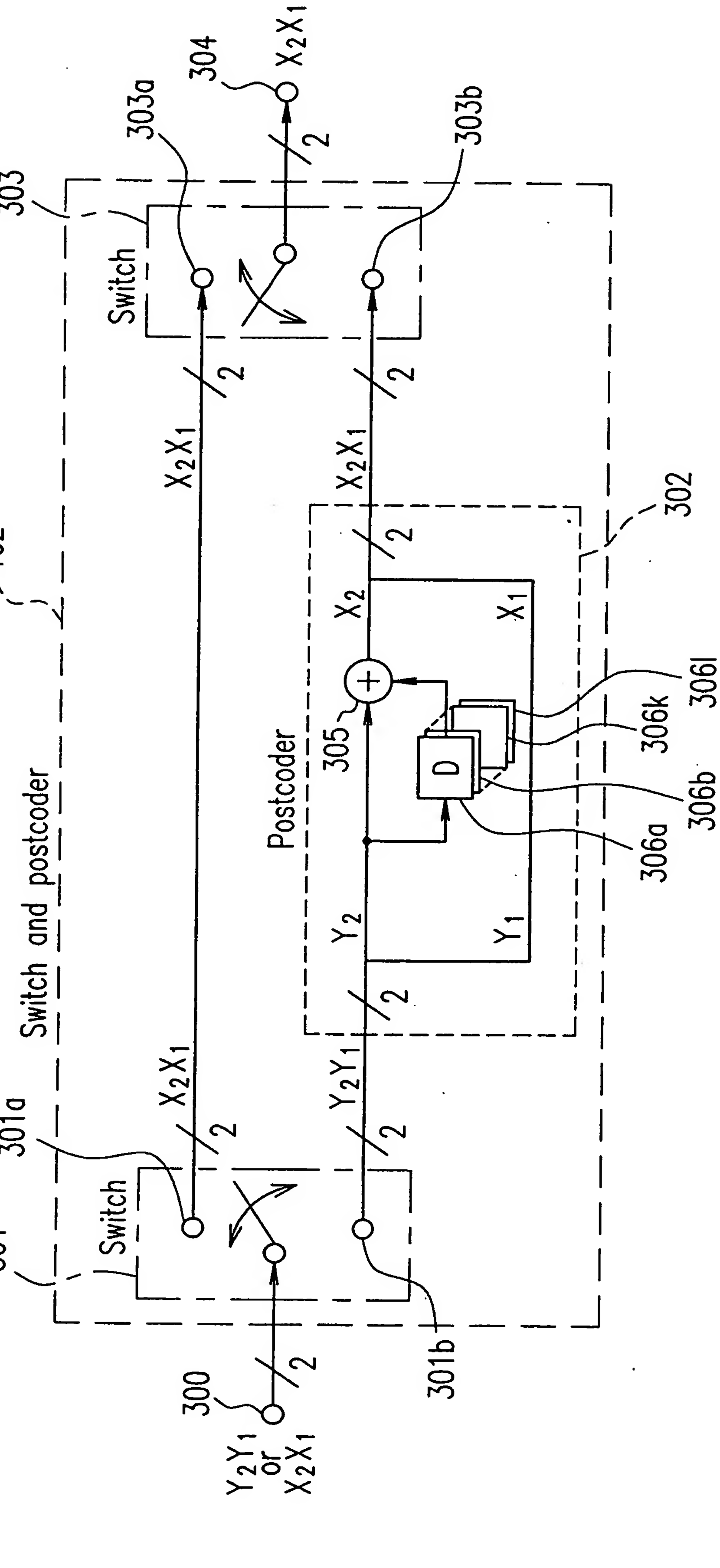

102
Switch and postcoder
301
Switch
301a
301b
300
Y_2Y_1 or X_2X_1
2
X_2X_1
Y_2Y_1
302
Postcoder
Y_2
Y_1
X_2
X_1
305
D
306a
306b
306k
306l
303
Switch
303a
303b
304
X_2X_1

FIG.5

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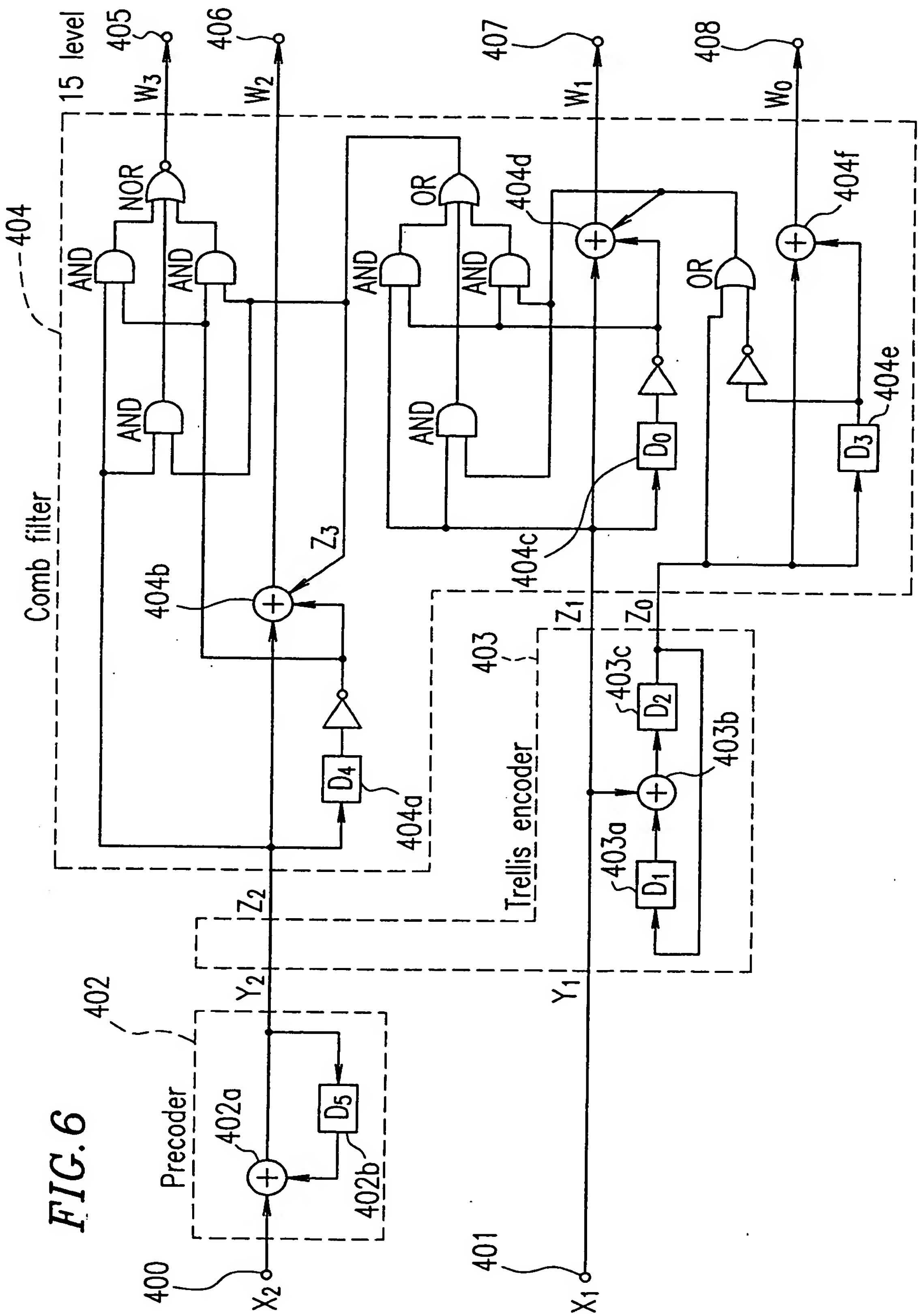

FIG. 6

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FIG. 7

4–state transition diagram

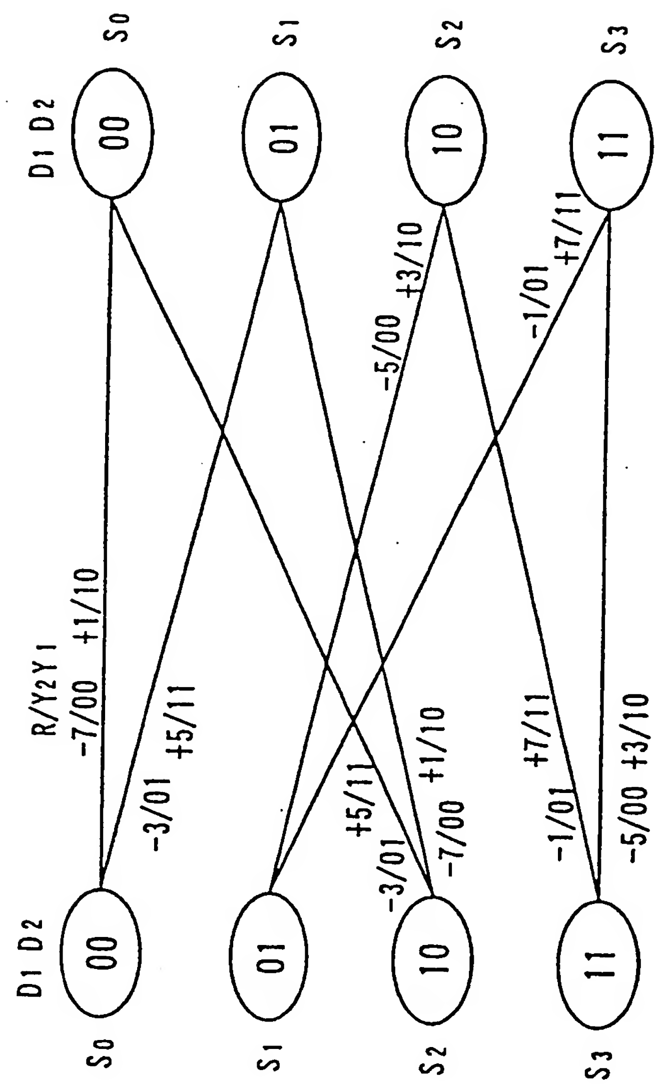

FIG. 8A

X_2	D_5 D_4	Y_2 Z_2	Z_3	W_3	W_2	Level
1	0	1	1	0	1	8,10,12,14
0	0	0	1	0	0	0,2,4,6
0	1	1	1	0	0	0,2,4,6
1	0	1	0	0	0	0,2,4,6
0	0	0	0	1	1	−8,−6,−4,−2
0	1	1	0	1	1	−8,−6,−4,−2
1	1	0	1	1	1	−8,−6,−4,−2
1	1	0	0	1	0	−14,−12,−10

FIG. 8B

Y_1 X_1	Z_3	W_1	W_0	Level
1	1	0	0	−8,0,8
0	1	0	0	−8,0,8
0	0	0	1	−14,−6,2,10
1	1	0	1	−14,−6,2,10
0	1	0	1	−14,−6,2,10
0	0	1	0	−12,−4,4,12
1	1	1	0	−12,−4,4,12
1	0	1	1	−10,−2,6,14
0	0	1	1	−10,−2,6,14
1	1	1	1	−10,−2,6,14

FIG. 9A

8–state transition diagram

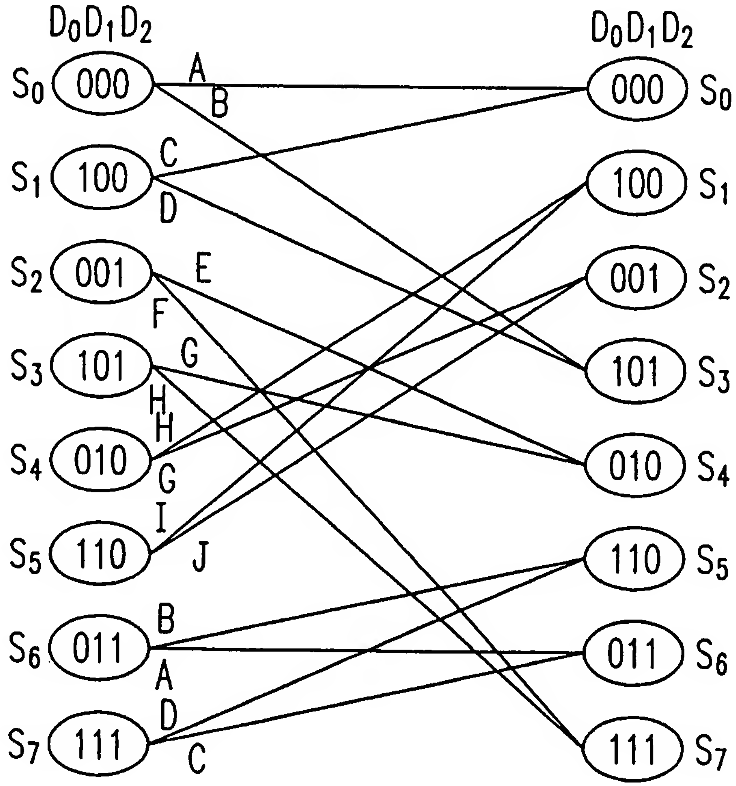

FIG. 9B

Level after being passed through comb filter

	MAP			
L	W_3	W_2	W_1	W_0
+14	0	1	1	1
+12	0	1	1	0
+10	0	1	0	1
+8	0	1	0	0
+6	0	0	1	1
+4	0	0	1	0
+2	0	0	0	1
0	0	0	0	0
−2	1	1	1	1
−4	1	1	1	0
−6	1	1	0	1
−8	1	1	0	0
−10	1	0	1	1
−12	1	0	1	0
−14	1	0	0	1

FIG. 9C

L/X_2X_1 for respective branches

	L/X_2X_1
A	-8/10, 0/00, +8/10
B	-4/11, +4/01, +12/11
C	-12/10, -4/00, +4/10
D	-8/11, 0/01, +8/11
E	-6/10, +2/00, +10/10
F	-2/11, +6/01, +14/11
G	-10/10, -2/00, +6/10
H	-6/11, +2/01, +10/11
I	-10/11, -2/01, +6/11
J	-14/10, -6/00, +2/10

FIG. 9D

State transition diagram used commonly for 8-state transition and 4-state transition

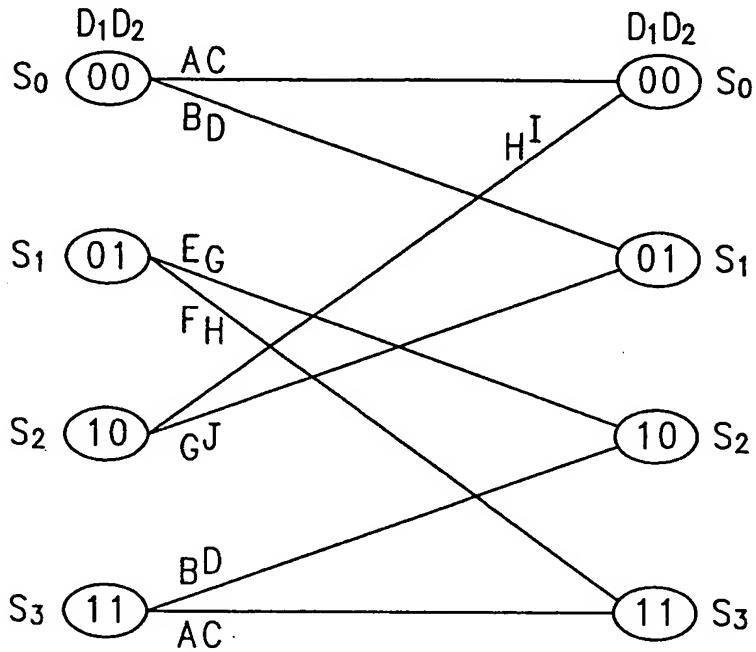

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FIG. 9E

L/X_2X_1 for respective branches

AC	−12 −8	−4 0	4 8
	10	00	10
BD	−8 −4	0 4	8 12
	11	01	11
EG	−10 −6	−2 2	6 10
	10	00	10
FH	−6 −2	2 6	10 14
	11	01	11
HI	−10 −6	−2 2	6 10
	11	01	11
GJ	−14 −10	−6 −2	2 6
	10	00	10

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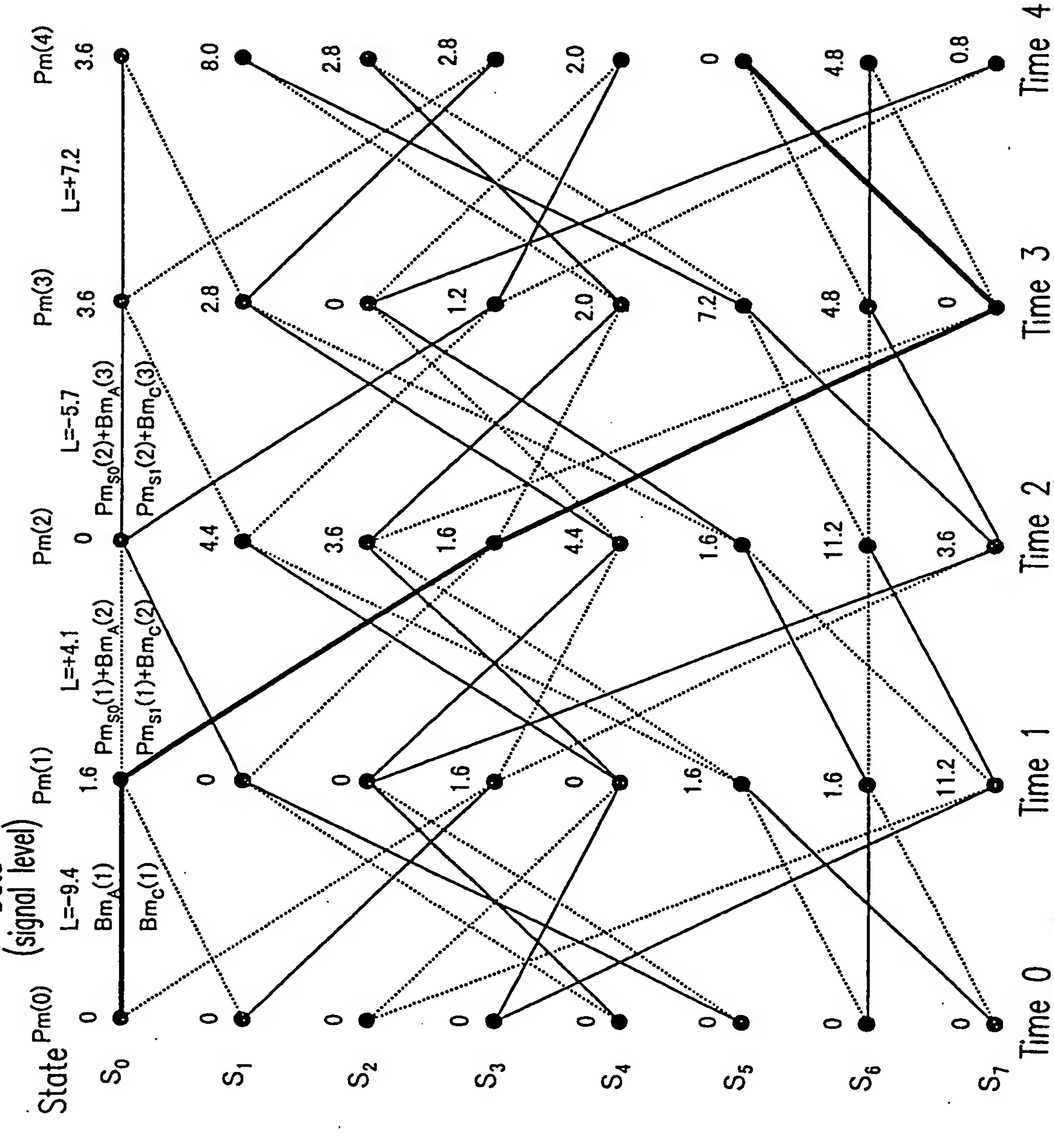

FIG. 10

FIG. 11A

State transition from time 0 to time 1 (L=−9.4)

Branch metric	L/X_2X_1	X_1/coset
$Bm_A(1)=(-9.4-(-8))^2=1.96$	−8/10	0/UA
$Bm_B(1)=(-9.4-(-4))^2=29.16$	−4/11	1/UC2
$Bm_C(1)=(-9.4-(-12))^2=6.76$	−12/10	0/UC1
$Bm_D(1)=(-9.4-(-8))^2=1.96$	−8/11	1/UA
$Bm_E(1)=(-9.4-(-6))^2=11.56$	−6/10	0/UD2
$Bm_F(1)=(-9.4-(-2))^2=54.76$	−2/11	1/UB2
$Bm_G(1)=(-9.4-(-10))^2=0.36$	−10/10	0/UB1
$Bm_H(1)=(-9.4-(-6))^2=11.56$	−6/11	1/UD2
$Bm_I(1)=(-9.4-(-10))^2=0.36$	−10/11	1/UB1
$Bm_J(1)=(-9.4-(-6))^2=11.56$	−6/00	0/UD1

FIG. 11B

State	Comparison of path metric (Pm(0)+Bm(1)=Bm(1), where Pm(0)=0)	Path metric Pm(1)
S_0	$Bm_A(1)= 1.96 < Bm_C(1)= 6.76$	$Pm_{S0}(1)=1.96-0.36=1.6$
S_1	$Bm_H(1)=11.56 > Bm_I(1)= \underline{0.36}$	$Pm_{S1}(1)=0.36-0.36=0$
S_2	$Bm_G(1)= \underline{0.36} < Bm_J(1)= 11.56$	$Pm_{S2}(1)=0.36-0.36=0$
S_3	$Bm_B(1)=29.16 > Bm_D(1)= 1.96$	$Pm_{S3}(1)=1.96-0.36=1.6$
S_4	$Bm_E(1)=11.56 > Bm_G(1)= \underline{0.36}$	$Pm_{S4}(1)=0.36-0.36=0$
S_5	$Bm_B(1)=29.16 > Bm_D(1)= 1.96$	$Pm_{S5}(1)=1.96-0.36=1.6$
S_6	$Bm_A(1)= 1.96 < Bm_C(1)= 6.76$	$Pm_{S6}(1)=1.96-0.36=1.6$
S_7	$Bm_F(1)=54.76 > Bm_H(1)= 11.56$	$Pm_{S7}(1)=11.56-0.36=11.2$

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FIG. 12A

State transition from time 1 to time 2 (L=+4.1)

Branch metric	L/X_2X_1	X_1/coset
$Bm_A(2)=(+4.1-(+8))^2=15.21$	+8/10	0/UA
$Bm_B(2)=(+4.1-(+4))^2=0.01$	+4/01	1/UC2
$Bm_C(2)=(+4.1-(+4))^2=0.01$	+4/10	0/UC1
$Bm_D(2)=(+4.1-(+8))^2=15.21$	+8/11	1/UA
$Bm_E(2)=(+4.1-(+2))^2=4.41$	+2/00	0/UD2
$Bm_F(2)=(+4.1-(+6))^2=3.61$	+6/01	1/UB2
$Bm_G(2)=(+4.1-(+6))^2=3.61$	+6/10	0/UB1
$Bm_H(2)=(+4.1-(+2))^2=4.41$	+2/01	1/UD2
$Bm_I(2)=(+4.1-(+6))^2=3.61$	+6/11	1/UB1
$Bm_J(2)=(+4.1-(+2))^2=4.41$	+2/10	0/UD1

FIG. 12B

State	Comparison of path metric (Pm(1)+Pm(2))	Path metric Pm(2)
S_0	$Pm_{S0}(1)+Bm_A(2)=16.81 > Pm_{S1}(1)+Bm_C(2)=\underline{0.01}$	$Pm_{S0}(2)=0.01-0.01=0$
S_1	$Pm_{S4}(1)+Bm_H(2)=4.41 < Pm_{S5}(1)+Bm_I(2)=5.21$	$Pm_{S1}(2)=4.41-0.01=4.4$
S_2	$Pm_{S4}(1)+Bm_G(2)=3.61 < Pm_{S5}(1)+Bm_J(2)=6.01$	$Pm_{S2}(2)=3.61-0.01=3.6$
S_3	$Pm_{S0}(1)+Bm_B(2)=1.61 < Pm_{S1}(1)+Bm_D(2)=15.21$	$Pm_{S3}(2)=1.61-0.01=1.6$
S_4	$Pm_{S2}(1)+Bm_E(2)=4.41 < Pm_{S3}(1)+Bm_G(2)=5.21$	$Pm_{S4}(2)=4.41-0.01=4.4$
S_5	$Pm_{S6}(1)+Bm_B(2)=1.61 < Pm_{S7}(1)+Bm_D(2)=26.41$	$Pm_{S5}(2)=1.61-0.01=1.6$
S_6	$Pm_{S6}(1)+Bm_A(2)=16.81 > Pm_{S7}(1)+Bm_C(2)=11.21$	$Pm_{S6}(2)=11.21-0.01=11.2$
S_7	$Pm_{S2}(1)+Bm_F(2)=3.61 < Pm_{S3}(1)+Bm_H(2)=6.01$	$Pm_{S7}(2)=3.61-0.01=3.6$

FIG. 13A

State transition from time 2 to time 3 (L=−5.7)

Branch metric	L/X_2X_1	X_1/coset
$Bm_A(2)=(-5.7-(-8))^2=5.29$	−8/10	0/UA
$Bm_B(2)=(-5.7-(-4))^2=2.89$	−4/11	1/UC2
$Bm_C(2)=(-5.7-(-4))^2=2.89$	−4/00	0/UC1
$Bm_D(2)=(-5.7-(-8))^2=5.29$	−8/11	1/UA
$Bm_E(2)=(-5.7-(-6))^2=0.09$	−6/10	0/UD2
$Bm_F(2)=(-5.7-(-2))^2=13.69$	−2/11	1/UB2
$Bm_G(2)=(-5.7-(-2))^2=13.69$	−2/10	0/UB1
$Bm_H(2)=(-5.7-(-6))^2=0.09$	−6/11	1/UD2
$Bm_I(2)=(-5.7-(-2))^2=13.69$	−2/01	1/UB1
$Bm_J(2)=(-5.7-(-6))^2=0.09$	−6/00	0/UD1

FIG. 13B

State	Comparison of path metric (Pm(2)+Pm(3))	Path metric Pm(3)
S_0	$Pm_{S0}(2)+Bm_A(3)=5.29 < Pm_{S1}(2)+Bm_C(3)=7.29$	$Pm_{S0}(3)=5.29-1.69=3.6$
S_1	$Pm_{S4}(2)+Bm_H(3)=4.49 < Pm_{S5}(2)+Bm_I(3)=15.29$	$Pm_{S1}(3)=4.49-1.69=2.8$
S_2	$Pm_{S4}(2)+Bm_G(3)=18.09 > Pm_{S5}(2)+Bm_J(3)=\underline{1.69}$	$Pm_{S2}(3)=1.69-1.69=0$
S_3	$Pm_{S0}(2)+Bm_B(3)=2.89 < Pm_{S1}(2)+Bm_D(3)=9.69$	$Pm_{S3}(3)=2.89-1.69=1.2$
S_4	$Pm_{S2}(2)+Bm_E(3)=3.69 < Pm_{S3}(2)+Bm_G(3)=15.29$	$Pm_{S4}(3)=3.69-1.69=2.0$
S_5	$Pm_{S6}(2)+Bm_B(3)=14.09 > Pm_{S7}(2)+Bm_D(3)=8.89$	$Pm_{S5}(3)=8.89-1.69=7.2$
S_6	$Pm_{S6}(2)+Bm_A(3)=16.49 > Pm_{S7}(2)+Bm_C(3)=6.49$	$Pm_{S6}(3)=6.49-1.69=4.8$
S_7	$Pm_{S2}(2)+Bm_F(3)=17.29 > Pm_{S3}(2)+Bm_H(3)=\underline{1.69}$	$Pm_{S7}(3)=1.69-1.69=0$

FIG. 14A

State transition from time 3 to time 4 (L=+7.2)

Branch metric	L/X_2X_1	X_1/coset
$Bm_A(4)=(+7.2-(+8))^2=0.64$	+8/10	0/UA
$Bm_B(4)=(+7.2-(+4))^2=10.24$	+4/01	1/UC2
$Bm_C(4)=(+7.2-(+4))^2=10.24$	+4/10	0/UC1
$Bm_D(4)=(+7.2-(+8))^2=0.64$	+8/11	1/UA
$Bm_E(4)=(+7.2-(+10))^2=7.84$	+10/10	0/UD2
$Bm_F(4)=(+7.2-(+6))^2=1.44$	+6/01	1/UB2
$Bm_G(4)=(+7.2-(+6))^2=1.44$	+6/10	0/UB1
$Bm_H(4)=(+7.2-(+10))^2=7.84$	+10/11	1/UD2
$Bm_I(4)=(+7.2-(+6))^2=1.44$	+6/11	1/UB1
$Bm_J(4)=(+7.2-(+2))^2=27.04$	+2/10	0/UD1

FIG. 14B

State	Comparison of path metric (Pm(3)+Pm(4))	Path metric Pm(4)
S_0	$Pm_{S0}(3)+Bm_A(4)=4.24 < Pm_{S1}(3)+Bm_C(4)=13.04$	$Pm_{S0}(4)=4.24-0.64=3.6$
S_1	$Pm_{S4}(3)+Bm_H(4)=9.84 > Pm_{S5}(3)+Bm_I(4)=8.64$	$Pm_{S1}(4)=8.64-0.64=8.0$
S_2	$Pm_{S4}(3)+Bm_G(4)=3.44 < Pm_{S5}(3)+Bm_J(4)=34.24$	$Pm_{S2}(4)=3.44-0.64=2.8$
S_3	$Pm_{S0}(3)+Bm_B(4)=13.84 > Pm_{S1}(3)+Bm_D(4)=3.44$	$Pm_{S3}(4)=3.44-0.64=2.8$
S_4	$Pm_{S2}(3)+Bm_E(4)=7.84 > Pm_{S3}(3)+Bm_G(4)=2.64$	$Pm_{S4}(4)=2.64-0.64=2.0$
S_5	$Pm_{S6}(3)+Bm_B(4)=15.04 > Pm_{S7}(3)+Bm_D(4)=\underline{0.64}$	$Pm_{S5}(4)=0.64-0.64=0$
S_6	$Pm_{S6}(3)+Bm_A(4)=5.44 < Pm_{S7}(3)+Bm_C(4)=10.24$	$Pm_{S6}(4)=5.44-0.64=4.8$
S_7	$Pm_{S2}(3)+Bm_F(4)=1.44 < Pm_{S3}(3)+Bm_H(4)=9.04$	$Pm_{S7}(4)=1.44-0.64=0.8$

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FIG. 15A 8-state transition diagram

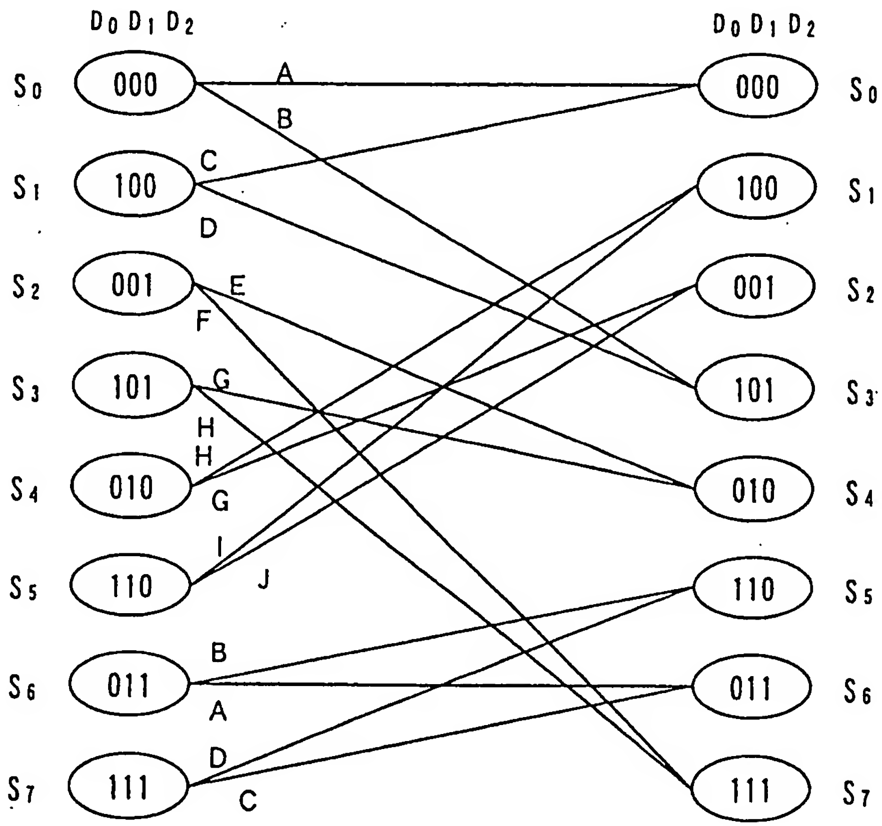

FIG. 15B Relationship between levels after being passed through comb filter and cosets

Coset	Level
UA	+8, 0, −8
UB1	+6, −2, −10
UB2	+14, +6, −2
UC1	+4, −4, −12
UC2	+12, +4, −4
UD1	+2, −6, −14
UD2	+10, +2, −6

FIG. 15C X_1/coset for respective branches

	X_1/coset
A	0/UA
B	1/UC2
C	0/UC1
D	1/UA
E	0/UD2
F	1/UB2
G	0/UB1
H	1/UD2
I	1/UB1
J	0/UD1

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Title: Error Correction Circuit and Error Correction Method
Customer No. 23122 Atty. Docket No. YAO-4210US1
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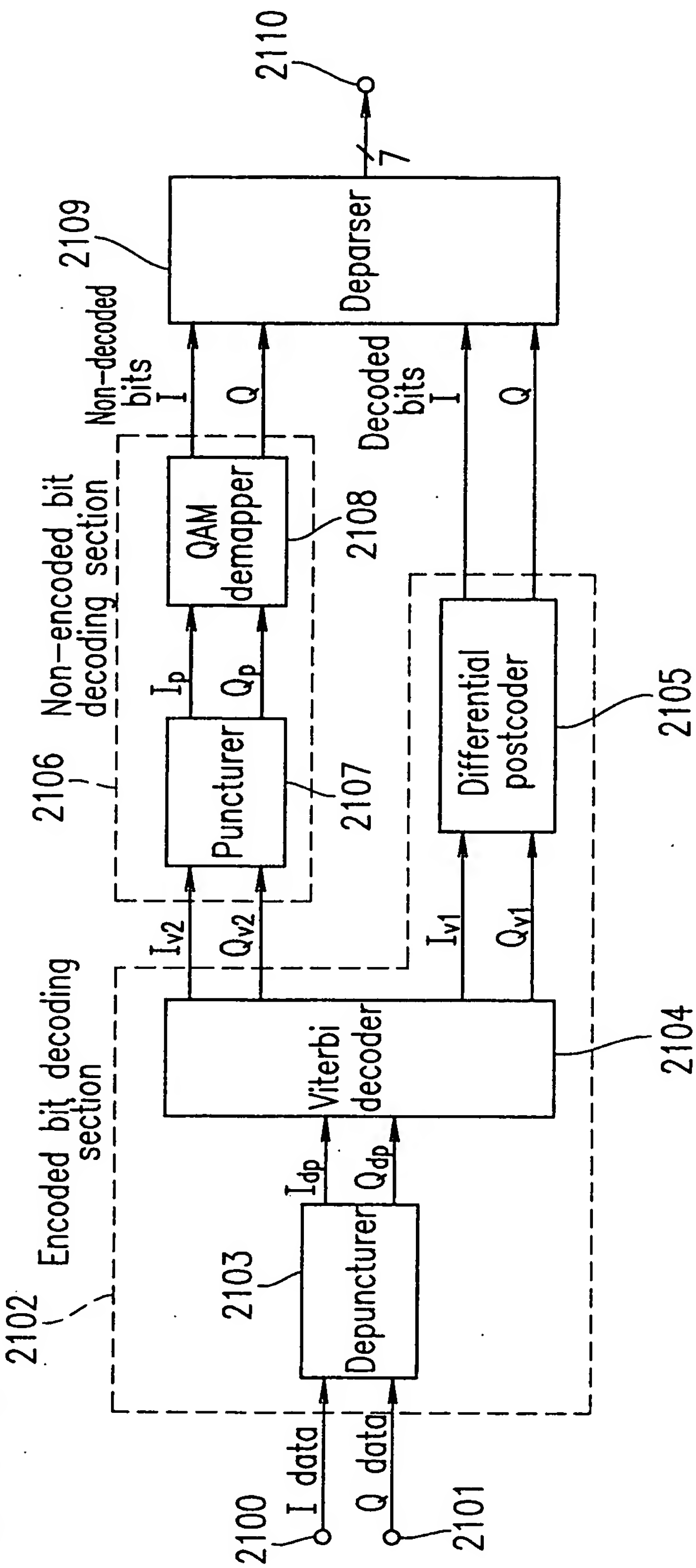
FIG. 16



Inventor(s): Hiroyuki Senda, et al.
Title: Error Correction Circuit and Error Correction Method
Customer No. 23122 Atty. Docket No. YAO-4210US1
Express Label No.: EV351884480US

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FIG. 17

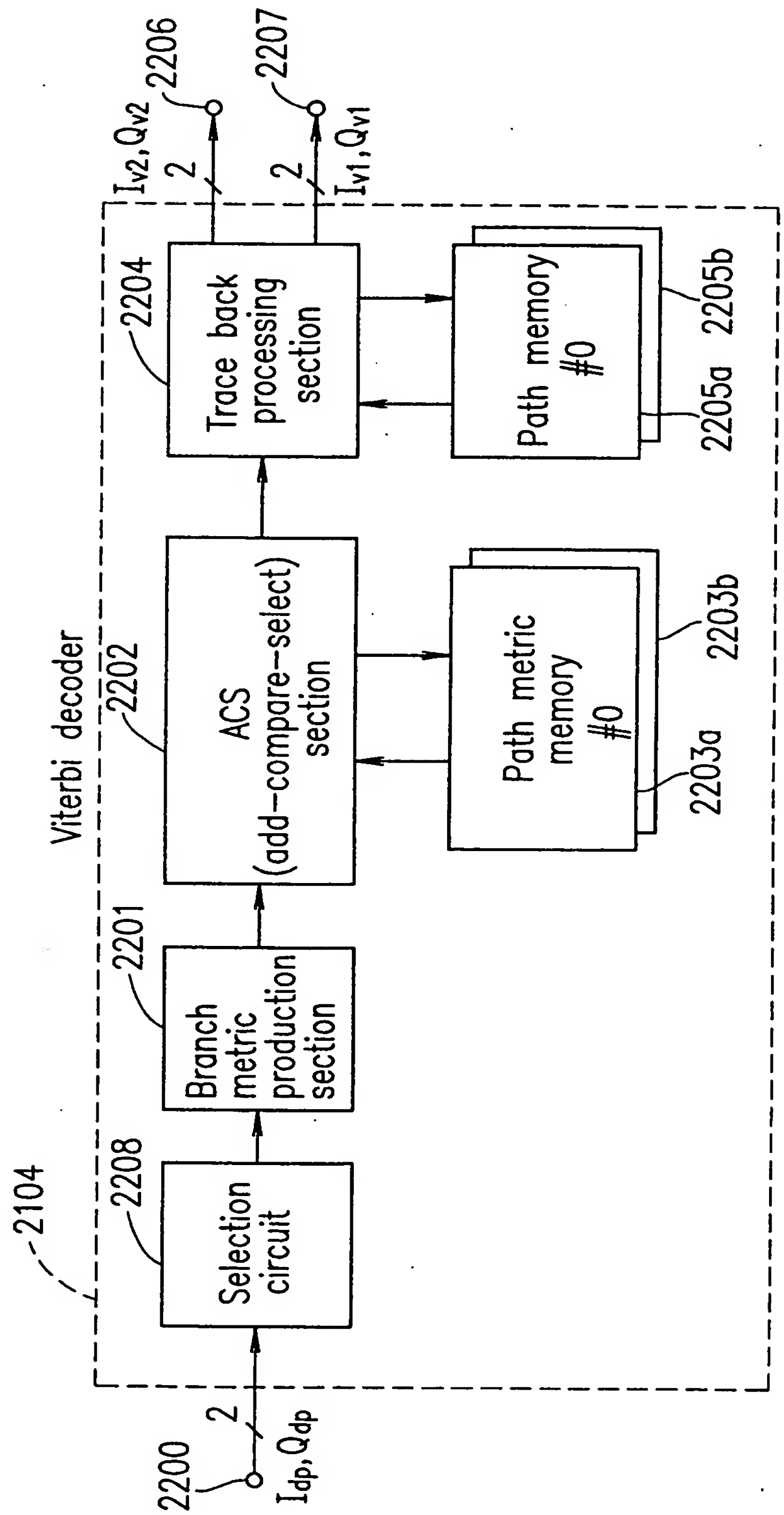

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FIG. 18A State transition diagram

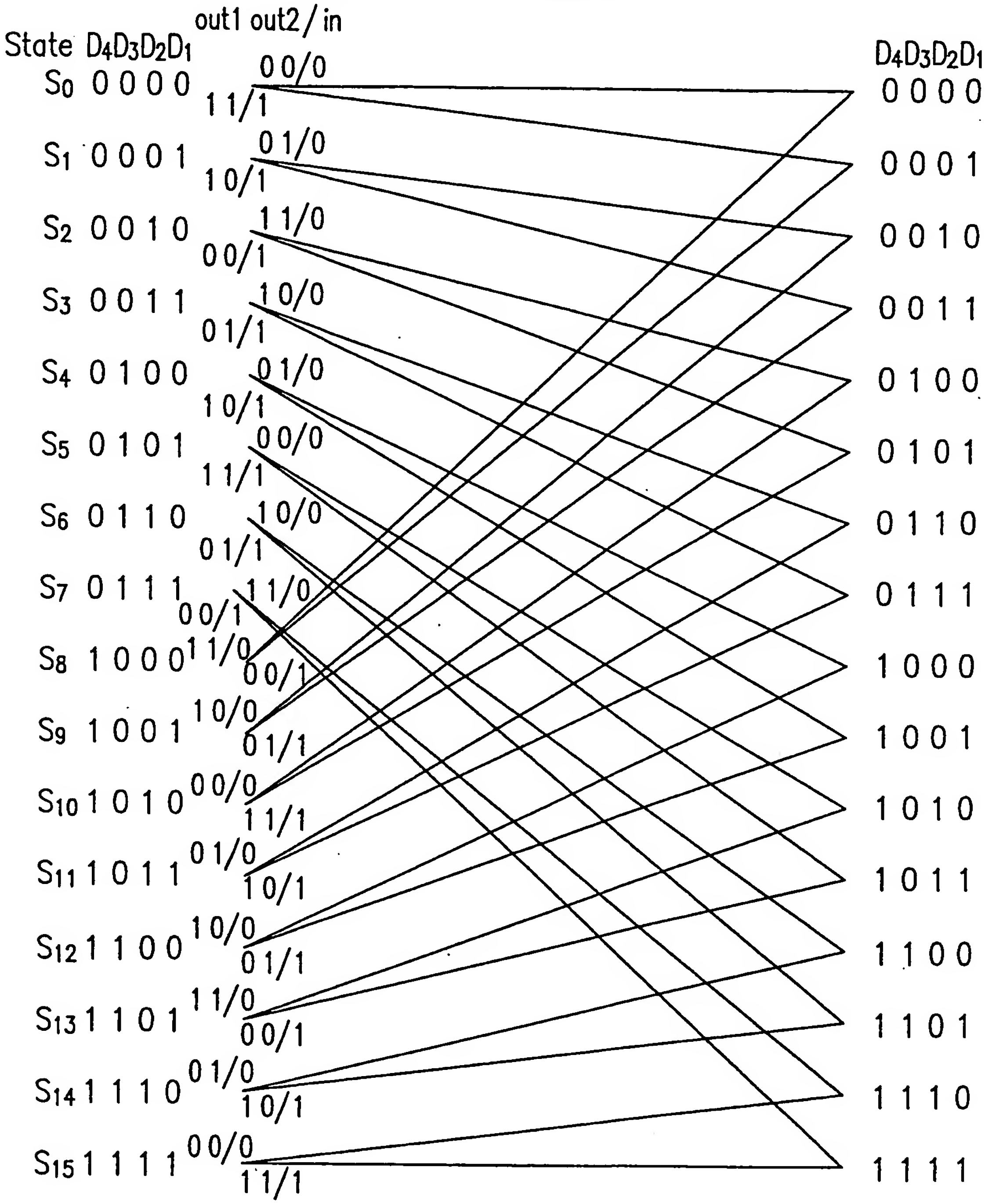
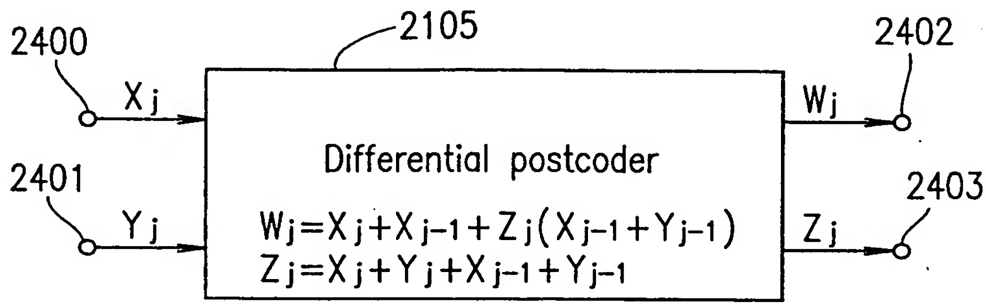


FIG. 18B Relationship between out1,out2 and signal level

out1,out2	Signal level
0	−7,−3,+1,+5
1	−5,−1,+3,+7

FIG. 19


2105
2400
2401
2402
2403
X_j
Y_j
W_j
Z_j
Differential postcoder
$W_j = X_j + X_{j-1} + Z_j(X_{j-1} + Y_{j-1})$
$Z_j = X_j + Y_j + X_{j-1} + Y_{j-1}$

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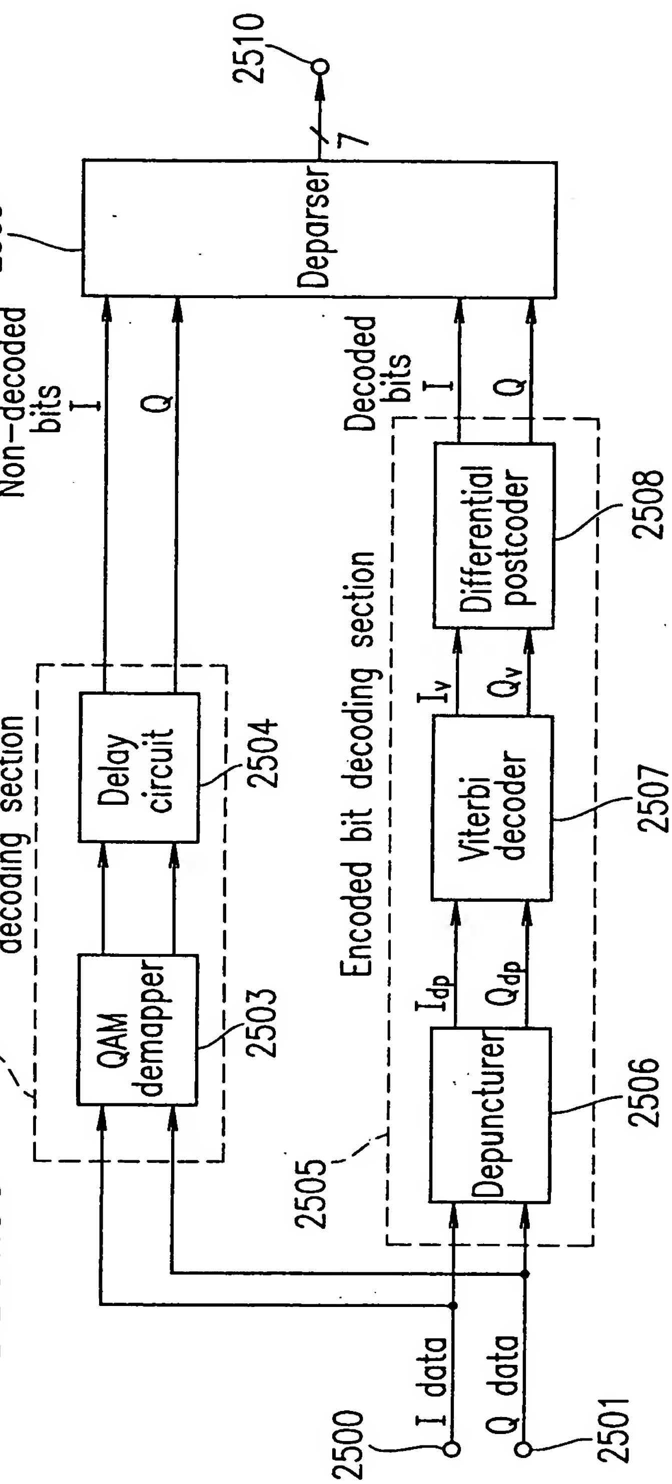

FIG. 20

FIG.21A Arrangement of 64QAM encoding points

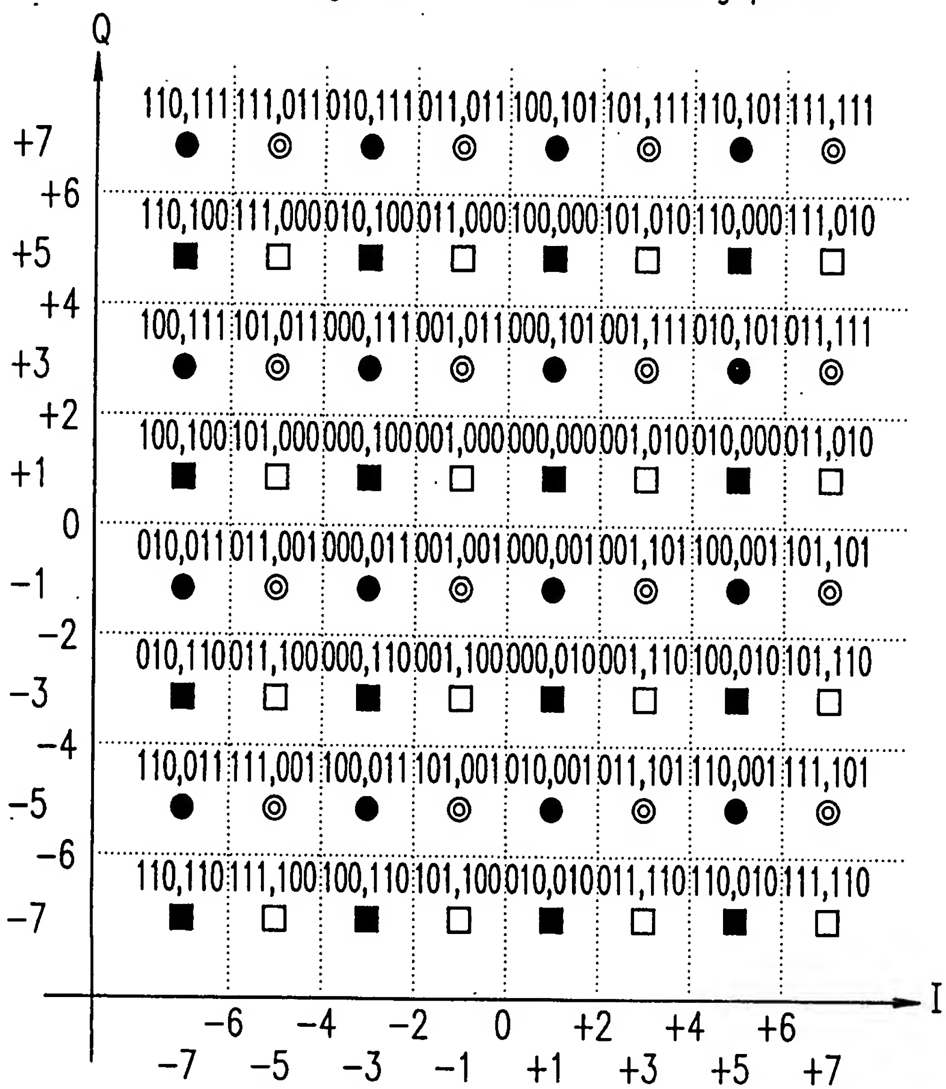

FIG.21B Encoding point

I bit Q bit

MSB LSB

(C(1) C(2) <u>C(3)</u> , C(4) C(5) <u>C(6)</u>)

FIG.21C

Encoded bits C(3),C(6)

	C(3)	C(6)
●	0	1
■	0	0
□	1	0
◎	1	1

"0"→ −7,−3,+1,+5

"1"→ −5,−1,+3,+7

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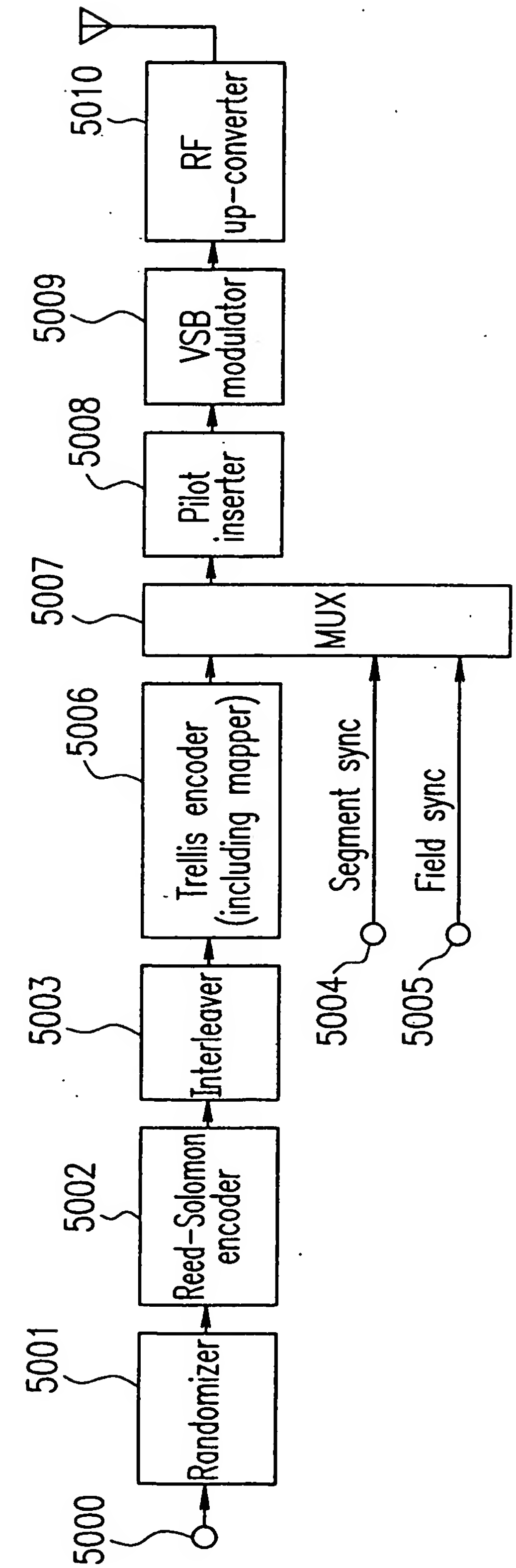

FIG.22
8VSB transmitter

Inventor(s): Hiroyuki Senda, et al.
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FIG.23

8VSB receiver

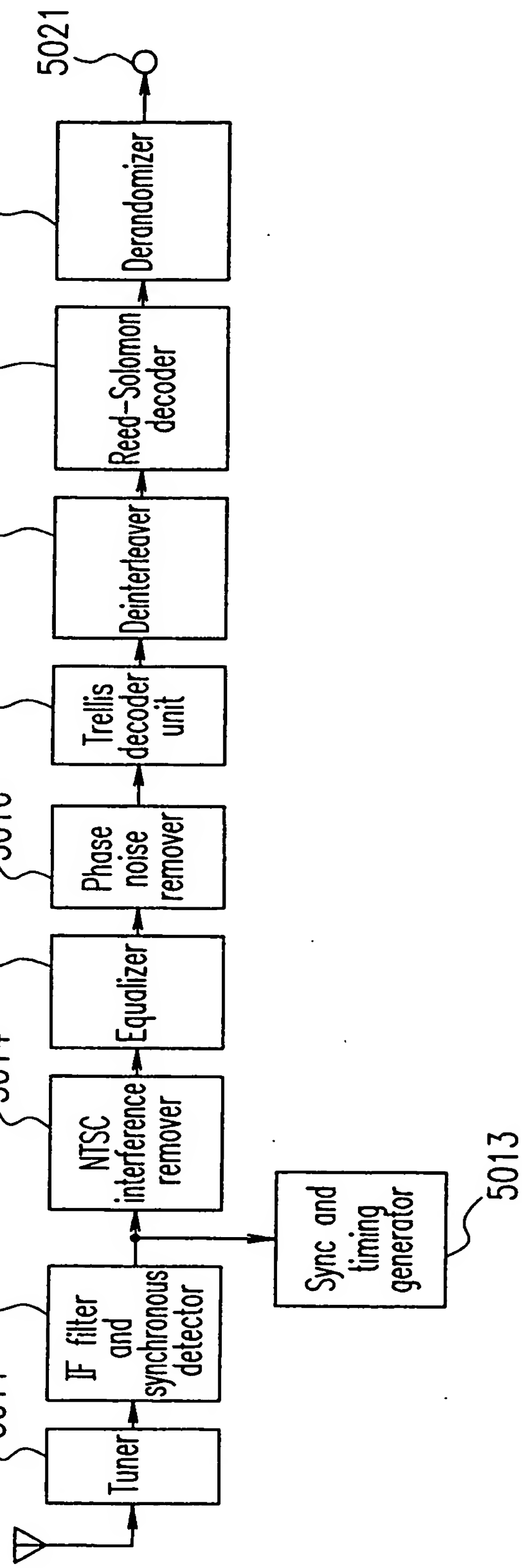

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FIG.24

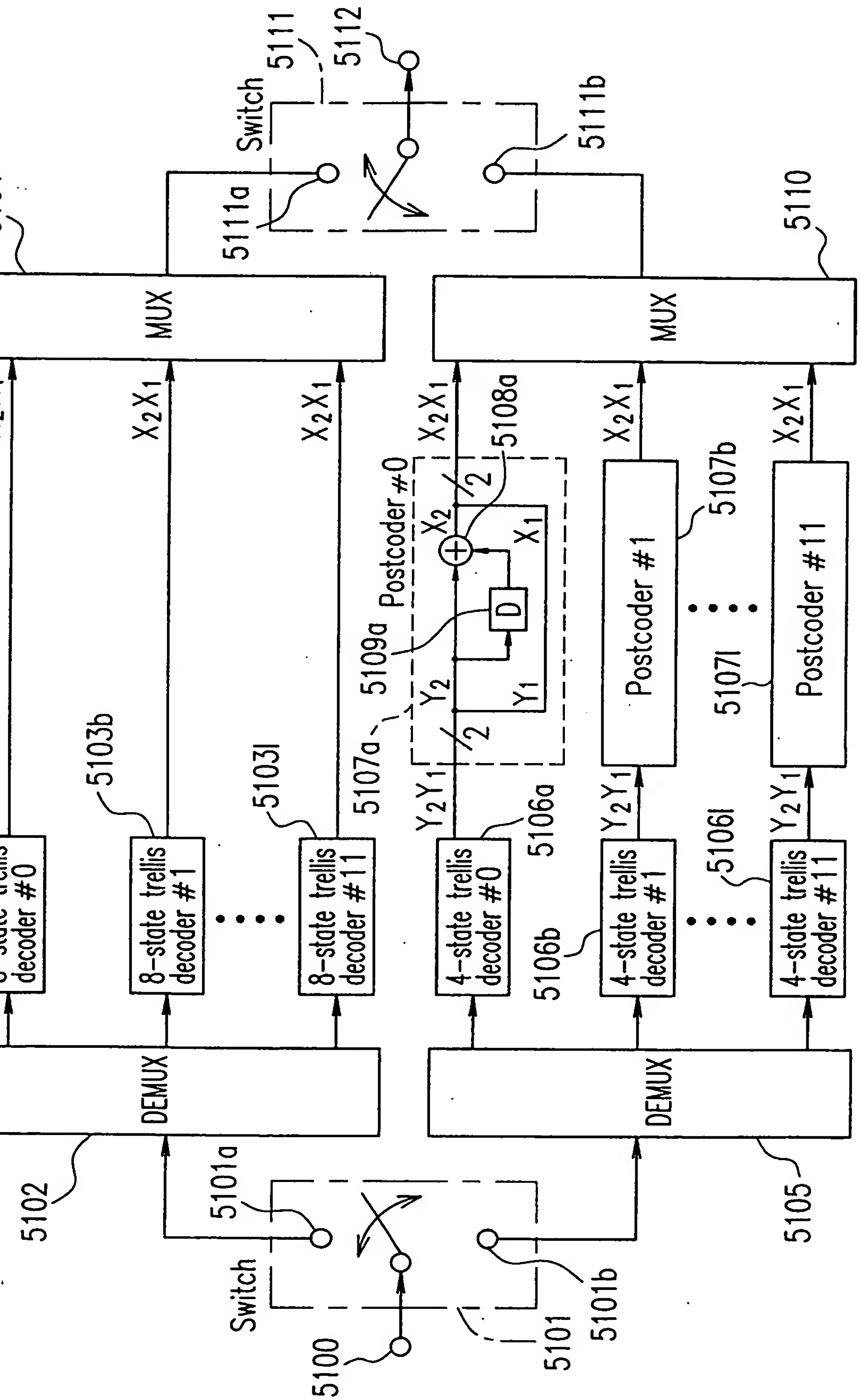

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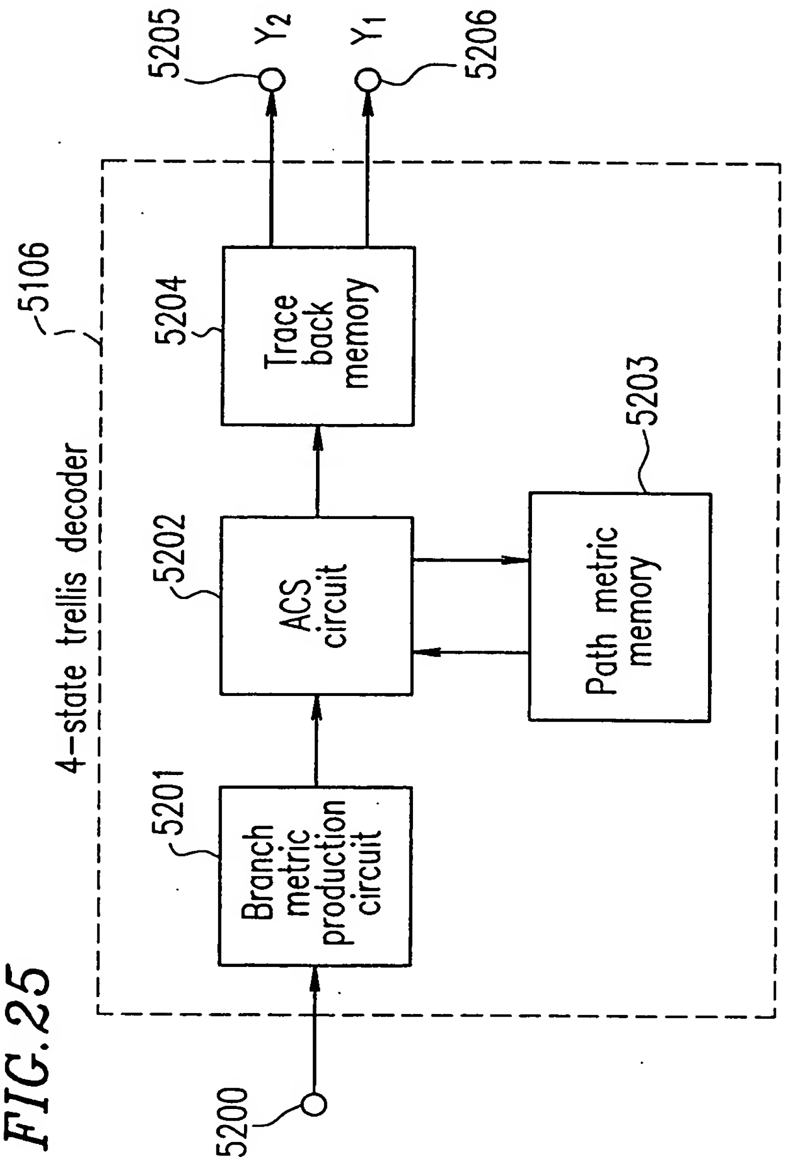
FIG.25



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Title: Error Correction Circuit and Error Correction Method
Customer No. 23122 Atty. Docket No. YAO-4210US1
Express Label No.: EV351884480US

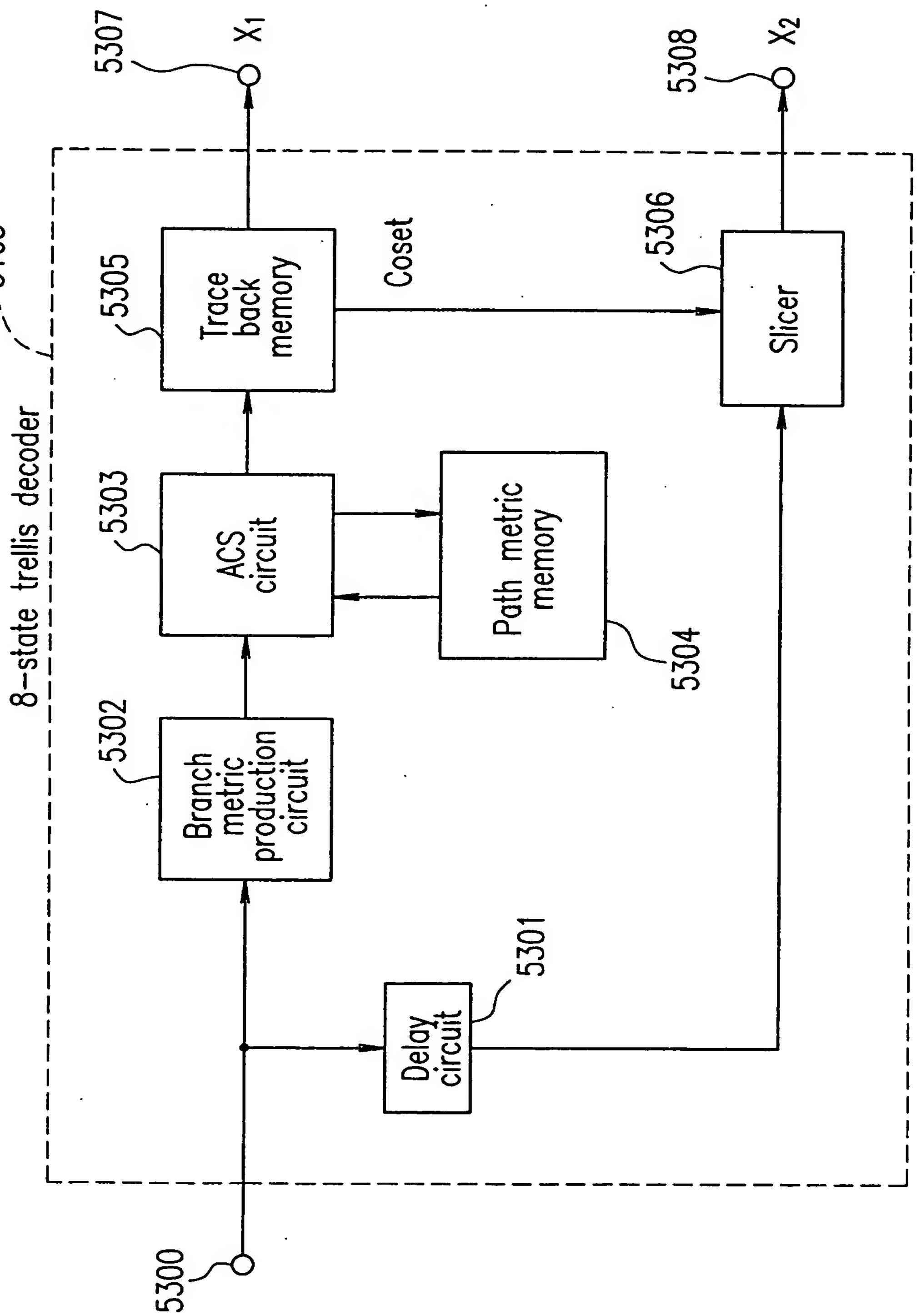

FIG.26

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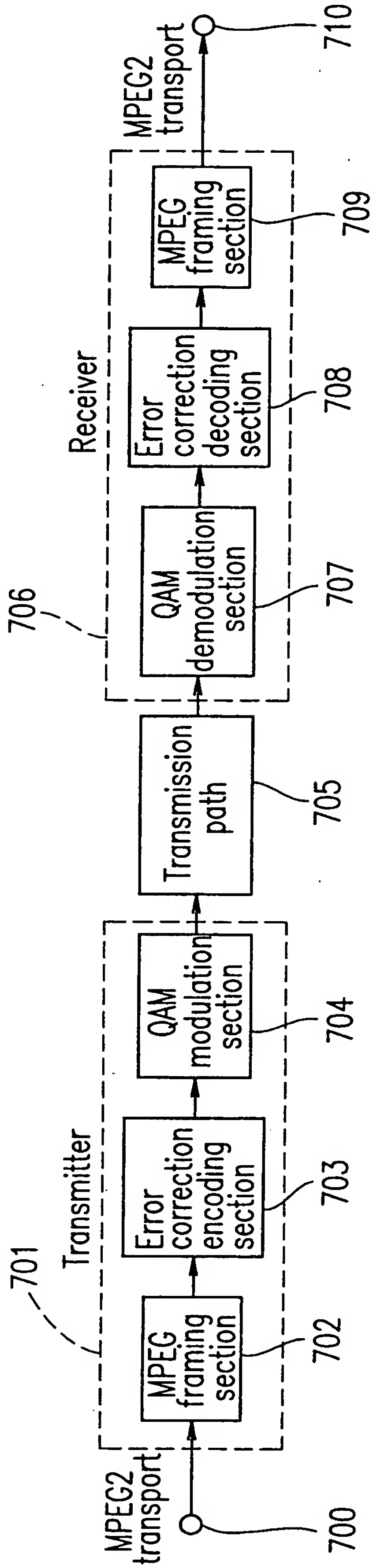

FIG.27

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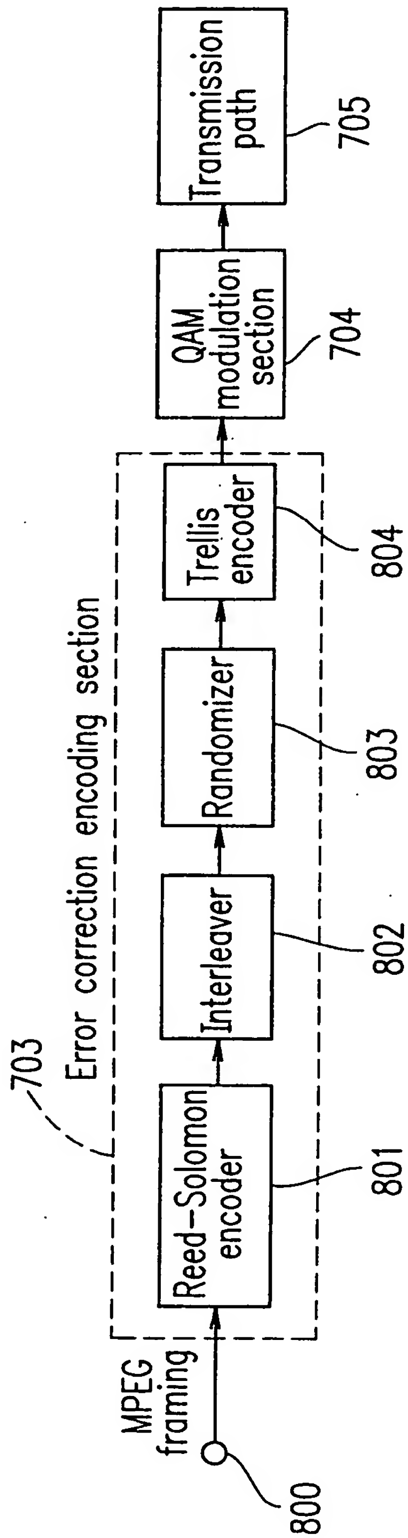
FIG.28A



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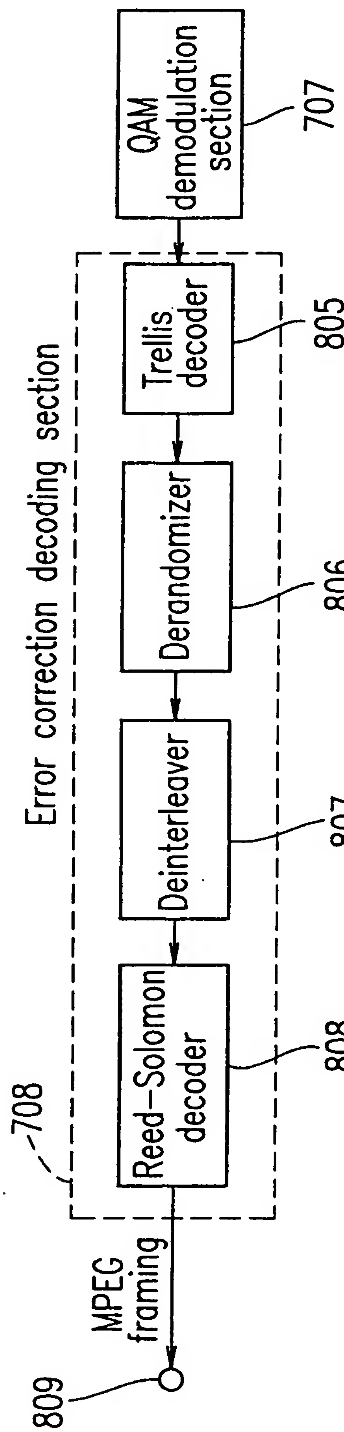

FIG.28B

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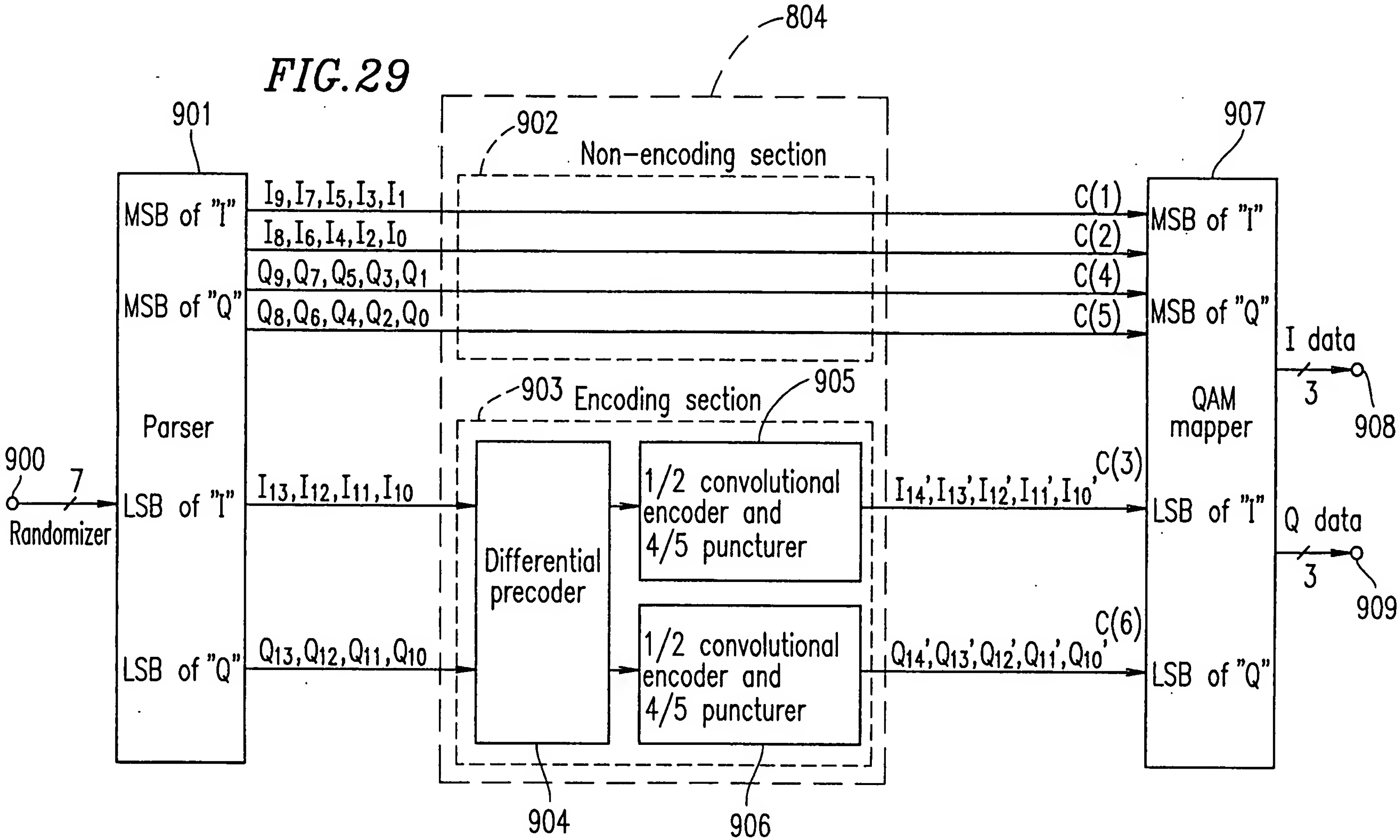
FIG.29



Inventor(s): Hiroyuki Senda, et al.
Title: Error Correction Circuit and Error Correction Method
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FIG.30

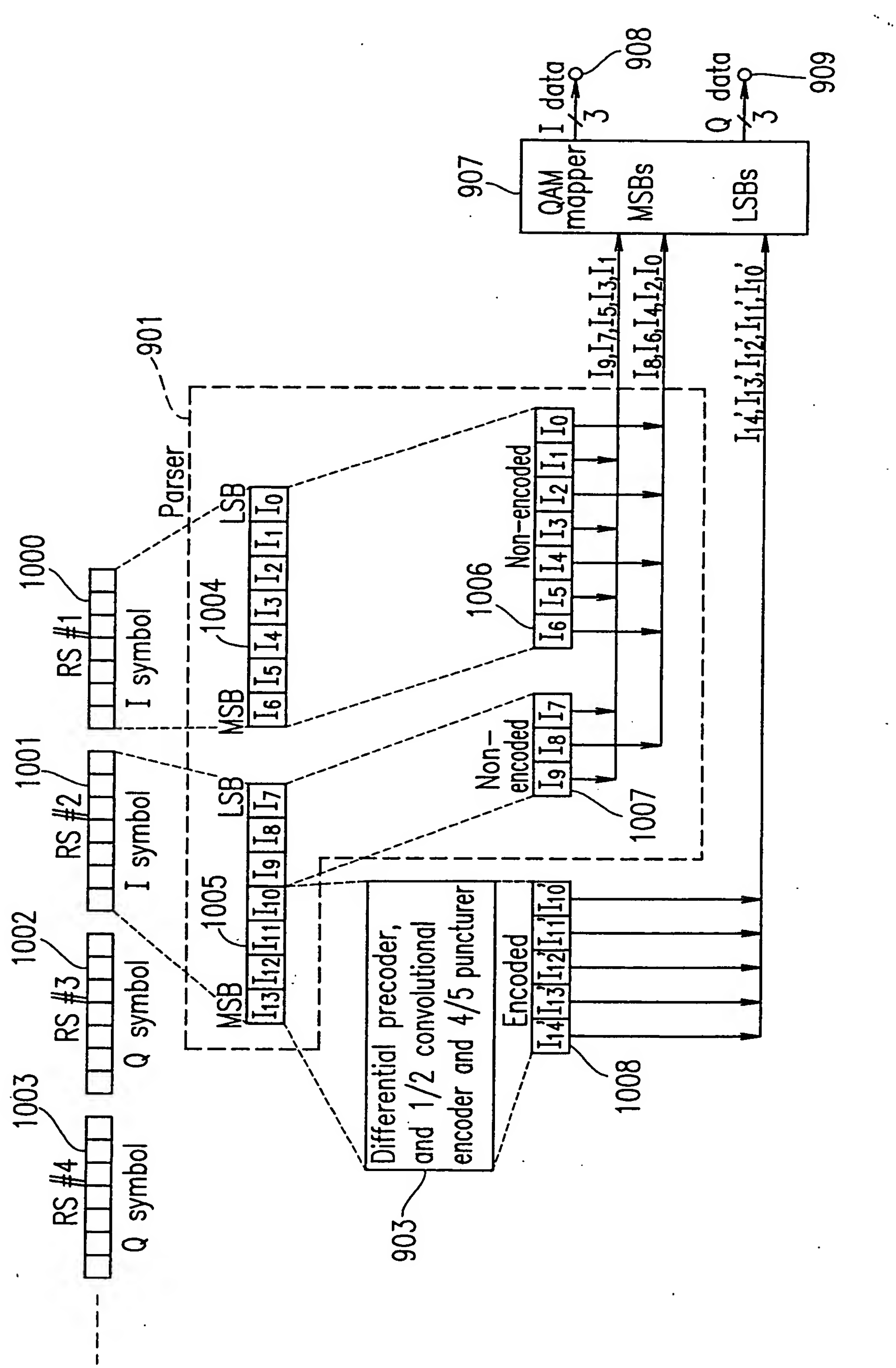
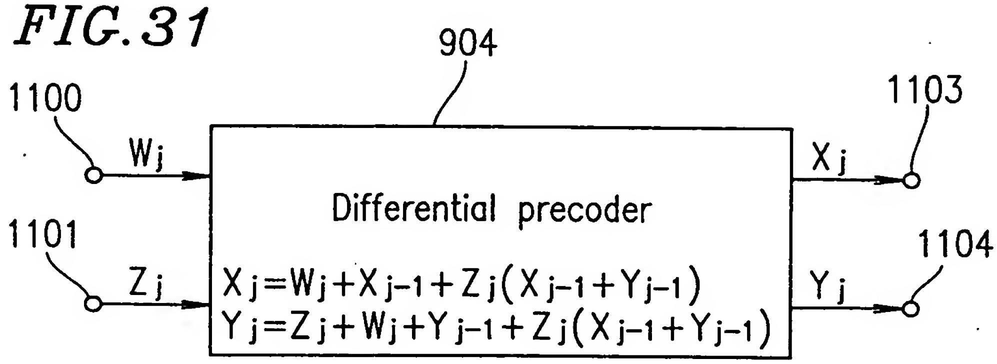


FIG.31


904
1100
1101
1103
1104
Wj
Zj
Xj
Yj
Differential precoder
Xj=Wj+Xj-1+Zj(Xj-1+Yj-1)
Yj=Zj+Wj+Yj-1+Zj(Xj-1+Yj-1)

Inventor(s): Hiroyuki Senda, et al.
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Customer No. 23122 Atty. Docket No. YAO-4210US1
Express Label No.: EV351884480US

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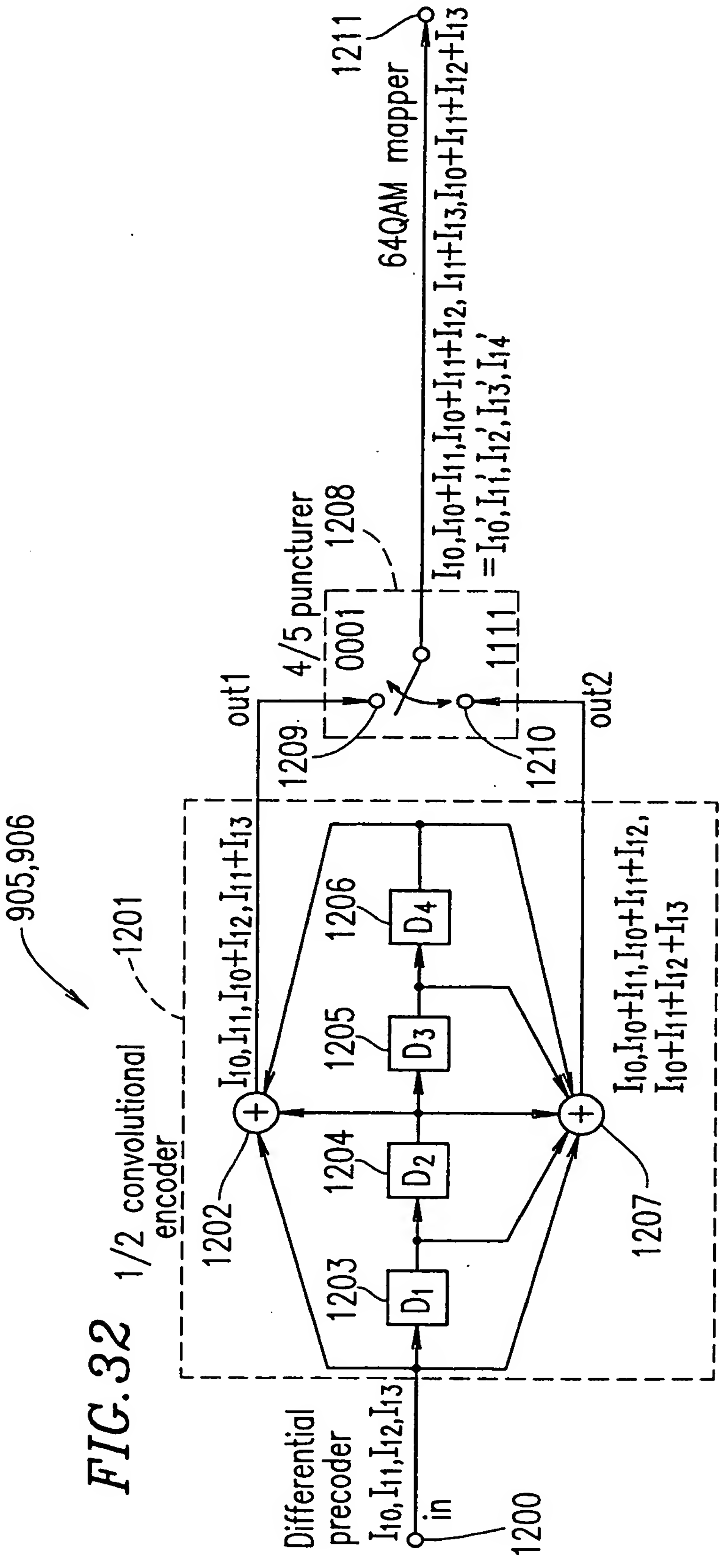

FIG. 32

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FIG.33A Arrangment of 64QAM encoding points

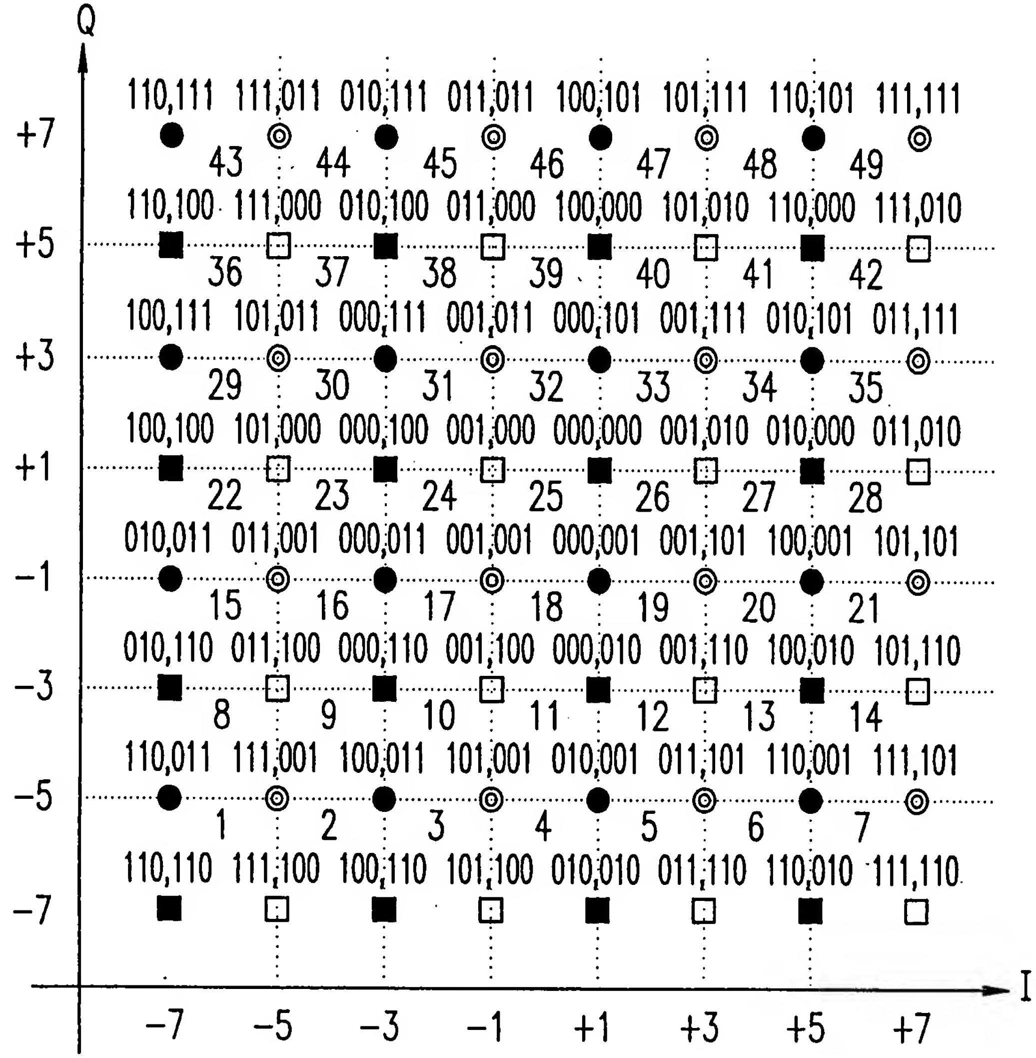

FIG.33B

Encoding point

I bit Q bit

MSB LSB

(C(1) C(2) C(3) ,C(4) C(5) C(6))

FIG.33C

Encoded bits C(3),C(6)

	C(3)	C(6)
●	0	1
■	0	0
□	1	0
◎	1	1

"0"→ −7,−3,+1,+5

"1"→ −5,−1,+3,+7

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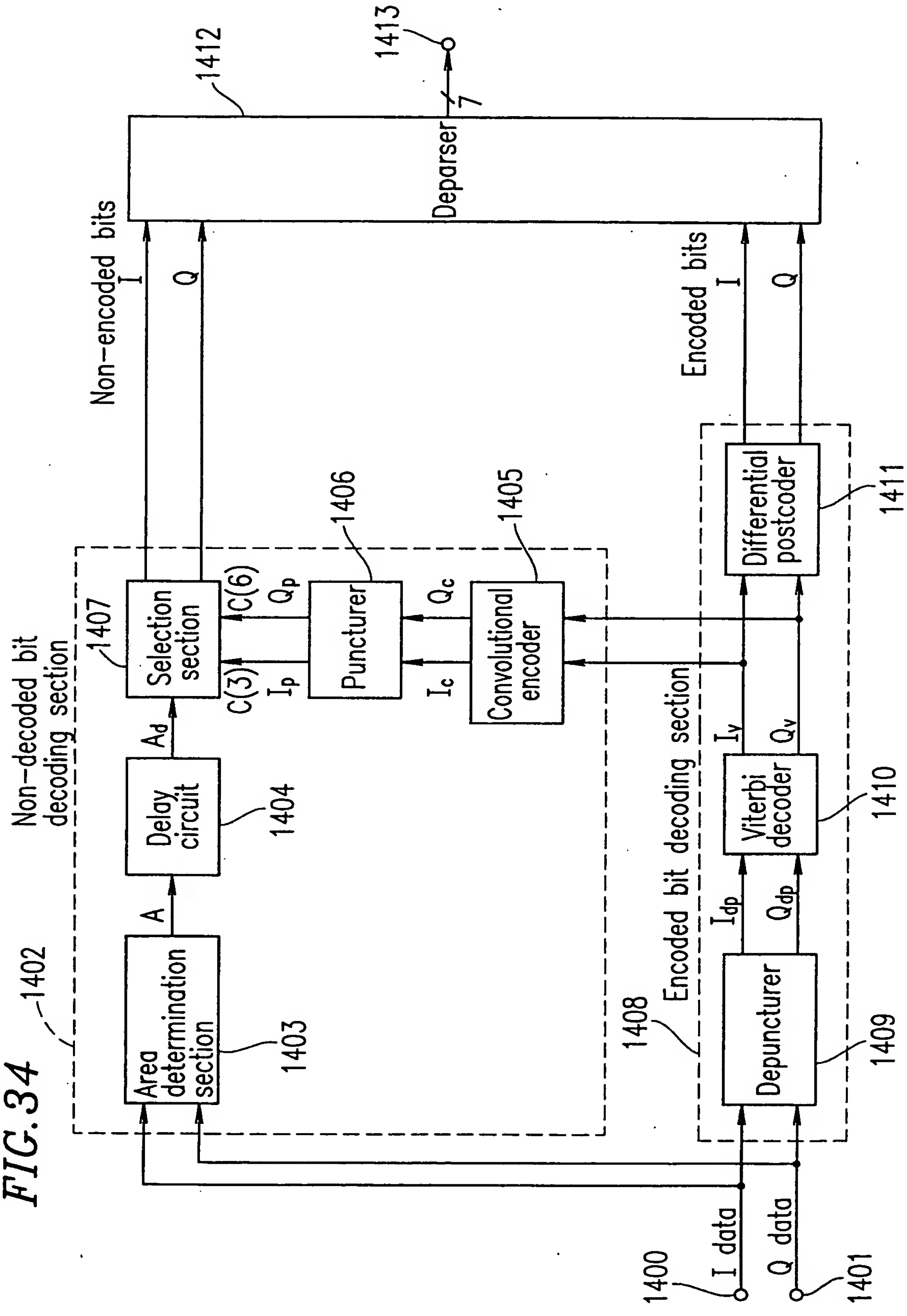

FIG. 34